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**SMITHSONIAN INSTITUTION
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SATELLITE ORBITAL DATA

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ETC-50,750

SATELLITE ORBITAL DATA¹

Orbital Information

The orbital elements tabulated below have been derived by the indicated staff members of the Satellite Tracking Program, Smithsonian Astrophysical Observatory, employing the Differential Orbit Improvement Program (DOI) of G. Veis and C. Moore.

As stated in the Notice of March 7, 1960, the orbital elements are incorrectly given in Special Report No. 31 (pages 2 to 7) for Satellites 1958 Alpha, 1958 81, 1958 82, 1958 62, 1959 41, and 1959 42. These data should be discarded and replaced by the correct elements included in the present report.

As opposed to osculating elements, the elements presented here are mean elements in the sense that the effects of the short period perturbations due to the earth's oblateness have been eliminated. These elements are called "SAO mean elements."

SAO mean elements have been derived from observations covering several days. The successive sets of elements are essentially independent of each other. They are dependent, however, in the sense that high-order coefficients in the secular and the long-periodic terms are generally considered as known and as constant for periods of several weeks or months, as dictated by convenience. Generally, these terms are sufficiently unimportant over several days that the orbits may be considered as truly independent.

The times of epoch in the mean elements are reckoned in Julian Days, but for the sake of convenience the number 2400000.5 has been subtracted in each case to provide an abbreviated notation which we call "Modified Julian Days," or "MJD."

Unless otherwise stated, the units of the orbital elements are degrees for angular quantities, megameters ($Mm = 10^6$ meters) for linear quantities, and revolutions for the mean anomaly M and its derivatives.

The tabulated values of the SAO mean elements give the values of arguments of perigee (ω), right ascension of the ascending node (Ω), inclination (i), eccentricity (e), and mean anomaly (M) as functions of time $t = T - T_0$ (where T_0 is the reference epoch) expressed in days.

The same tabulation also gives the mean (anomalistic) motion (n), the orbital acceleration ($n' = dn/dt$),² and the semimajor axis (a). The single digit placed at the right of each value represents the standard error for that element and refers to the last digit given.

SAO smoothed elements are derived either by a least-squares fit to the mean elements or directly by the DOI for the entire period they cover. These elements are used to obtain an approximate ephemeris when the accuracy of the mean elements is not required.

The elements are given as functions of time and they include in general both secular and periodic terms. The general expression for any element "b" is

¹ Material compiled by D. V. Mechau, Administrative Assistant, Computations Division; under the supervision of C. W. Tillinghast, Chief, Computations Division; and C. A. Whitney, Chief, Research and Analysis Division.

² Instead of n' sometimes the value of $1/2 n'$ is tabulated.

$$b = b_0 + b_1 t + b_2 t^2 + \dots + \sum A_i \sin (B_i + C_i t)$$

where $t = T - T_0$ is again expressed in days.

Since very often the effect of the third harmonic of the earth's potential is larger than the uncertainty of the elements, this effect may also be included in the form of $A \sin \omega$ or $B \cos \omega$.

The mean (anomalistic) motion n can be obtained from the smoothed elements by differentiating the expression for M , and the orbital acceleration $n' = dn/dt$ can be obtained by twice differentiating the same expression for M .

We repeat in part a note appearing in Special Report No. 28, page 7, on the orbital elements determined by the SAO Differential Orbit Improvement Program:

The reference plane is defined as the true equator of the date. The origin of right ascension is a line shifted from the mean equinox of the date by an amount equal to the precession in right ascension between 1950.0 and the date.

Given below is a formula with which values can be obtained to correct the right ascension given in the orbital elements, in a right ascension referring to the mean equinox of date:

$$\Delta^\circ(t) = \Delta^\circ(\text{DOI}) + 3^\circ 508 \times 10^{-5} (\text{MJD} - 33281),$$

where DOI indicates the values determined by the Differential Orbit Improvement Program, and distributed by the Smithsonian Astrophysical Observatory. MJD indicates the Modified Julian Day described above.

ORBITAL ELEMENTS FOR JULY AND AUGUST, 1959

Satellite 1958 Alpha (Explorer I)

Beatrice Miller

I. SAO smoothed elements

The following elements are based on 222 observations and are valid for the period July 1 through July 31, 1959.

$$\begin{aligned}
 T_0 &= 3676.0 \text{ MJD} \\
 \omega &= 335.77 + 6.8797 t - .8428 \times 10^{-3} t^2 - .218 \cos \omega \\
 \Omega &= 188.030 - 4.6032 t - .3038 \times 10^{-3} t^2 - .9015 \times 10^{-2} \cos \omega \\
 i &= 33.243 + .3839 \times 10^{-3} t + .1551 \times 10^{-4} t^2 - .494 \times 10^{-2} \sin \omega \\
 e &= .11974 - .1862 \times 10^{-4} t + .2978 \times 10^{-6} t^2 + .465 \times 10^{-3} \sin \omega \\
 M &= -.86902 + 13.048168 t + .5344 \times 10^{-3} t^2 + .6126 \times 10^{-3} \cos \omega
 \end{aligned}$$

Standard error of one observation: $\sigma = \pm 43'$.

The following elements are based on 75 observations and are valid for the period August 1 through August 31, 1959.

$$\begin{aligned}
 T_0 &= 36800.0 \text{ MJD} \\
 \omega &= 251.09 + 6.9364 t + .1454 \times 10^{-2} t^2 - .218 \cos \omega \\
 \Omega &= 3.314 - 4.6291 t - .2383 \times 10^{-3} t^2 - .9015 \times 10^{-2} \cos \omega \\
 i &= 33.232 - .4384 \times 10^{-3} t - .3162 \times 10^{-4} t^2 - .494 \times 10^{-2} \sin \omega \\
 e &= .11548 - .600 \times 10^{-4} t + .1178 \times 10^{-5} t^2 + .465 \times 10^{-3} \sin \omega \\
 M &= .85036 + 13.085072 t + .3944 \times 10^{-3} t^2 + .6126 \times 10^{-3} \cos \omega
 \end{aligned}$$

Standard error of one observation: $\sigma = \pm 30'$.

Estimated date of demise: January, 1963.

II. SAO mean elements, derived from observations covering a period of 6 days, ± 3 days from epoch.

T (MJD)	ω	Ω	i	e	M	n	n^t	B
36750.	267.51 2	-125.99 2	33.228 5	.1172 1	.6983 1	13.03883 1	.511E-3 7	7.62345
36754.	295.11 6	-144.47 2	33.224 7	.1170 2	-.1395 2	13.04222 1	.428E-3 6	7.62217
36758.	322.59 2	-162.842 7	33.225 3	.11664 8	-.96345 6	13.045753 4	.455E-3 2	7.62090
36762.	350.13 1	-181.247 7	33.224 2	.11661 6	.22725 5	13.049749 2	.521E-3 2	7.61898
36766.	377.64 3	-199.66 1	33.222 3	.11667 8	.4353 1	13.054604 3	.655E-3 2	7.61707
36770.	405.16 8	-218.07 4	33.24 1	.1170 3	-.3363 3	13.05938 1	.532E-3 8	7.61580
36774.	432.51 1	-236.53 2	33.231 6	.1168 1	.90978 7	13.063332 6	.471E-3 4	7.61388
36778.	460.0 2	-255.1 2	33.23 3	.1153 7	-.8290 3	13.06695 8	.44E-3 2	7.61261
36782.	127.2 1	86.52 8	33.24 2	.1159 4	.4462 3	13.07043 2	.42E-3 1	7.61133
36786.	154.7 5	68.12 4	33.22 2	.1158 8	-.266 2	13.073865 8	.445E-3 5	7.61005
36790.	183. 2	49.6 1	33.25 9	.117 3	.033 6	13.07748 4	.44E-3 3	7.60878
36794.	210. 4	31.1 2	33.2 3	.115 7	-.65 1	13.08042 9	.41E-3 7	7.60750
36798.	237.7 1	12.54 5	33.22 2	.1151 2	-.3193 2	13.08364 3	.39E-3 1	7.60623
36802.	265.9 2	-6.0 1	33.34 6	.1198 5	-.9798 5	13.08661 6	.40E-3 2	7.60495
36806.	293.3 1	-24.47 2	33.230 5	.1144 2	-.6264 3	13.08974 2	.397E-3 7	7.60368
36810.	321.16 8	-43.02 2	33.227 5	.1143 1	-.2613 2	13.092965 7	.416E-3 6	7.60240

I. SAO smoothed elements

The following elements are based on 240 observations and are valid for the period July 1 to July 31, 1959.

$$\begin{aligned}
 T_0 &= 36749.0 \text{ MJD} \\
 \omega &= 273.977 + 4.156t + .735 \times 10^{-5}t^2 + .1083 \cos \omega \\
 \Omega &= 262.051 - 2.844t - .503 \times 10^{-5}t^2 + .0133 \cos \omega \\
 i &= 34.260 - ? \times 10^{-2} \sin \omega \\
 e &= .20707 - .2627 \times 10^{-5}t + .4123 \times 10^{-3} \sin \omega \\
 M &= - .90972 + 10.3982t + .96 \times 10^{-5}t^2
 \end{aligned}$$

Standard error of one observation: $\sigma = \pm 3.8'$.

The following elements are based on 158 observations and are valid for the period August 1 to August 31, 1959.

$$\begin{aligned}
 T_0 &= 36780.0 \text{ MJD} \\
 \omega &= 42.816 + 4.146t + .735 \times 10^{-5}t^2 + .1083 \cos \omega \\
 \Omega &= 173.868 - 2.840t - .503 \times 10^{-5}t^2 + .0133 \cos \omega \\
 i &= 34.272 - ? \times 10^{-2} \sin \omega \\
 e &= .20725 - .2627 \times 10^{-5}t + .4123 \times 10^{-3} \sin \omega \\
 M &= - .55500 + 10.39885t + .96 \times 10^{-5}t^2
 \end{aligned}$$

Standard error of one observation: $\sigma = \pm 2.4'$.

Estimated date of demise: 2260.

II. SAO mean elements, derived from observations covering a period of 8 days, ± 4 days from epoch.

T (MJD)	ω	Ω	i	e	M	n	n'	a
36750.	278.21 2	259.202 8	34.252 3	.20710 6	.48818 2	10.39833 1	.068E-4 8	8.86535
36754.	294.81 1	247.840 6	34.250 2	.20702 6	.08155 2	10.39836 1	.09E-4 1	8.86533
36758.	311.444 9	236.454 4	34.251 2	.20692 4	-.32484 1	10.39844 1	.06E-4 1	8.86529
36762.	328.08 2	225.071 6	34.255 3	.20697 9	.26902 2	10.39848 1	.075E-4 9	8.86526
36766.	344.658 2	213.682 9	34.253 3	.20713 8	.86306 3	10.39855 2	.124E-4 9	8.86522
36770.	361.301 3	202.323 1	34.257 6	.2071 1	.54250 5	10.39867 2	.07E-4 2	8.86515
36774.	377.88 2	190.958 8	34.260 2	.20716 7	-.94768 2	10.39873 1	.09E-4 7	8.86512
36778.	394.476 7	179.576 4	34.260 1	.20721 4	.64741 1	10.39880 1	.09E-4 4	8.86508
36782.	51.082 8	168.210 6	34.264 1	.20725 4	.24276 1	10.39888 1	.080E-4 6	8.86503
36786.	67.680 8	156.845 6	34.269 2	.20726 4	.83841 1	10.39895 1	.118E-4 5	8.86499
36790.	84.3 1	145.43 6	34.233 2	.2066 2	-.5656 2	10.39907 8	.16E-4 1	8.86493
36794.	100.9 2	134.09 7	34.234 2	.20652 2	.0379 2	10.3991 2	.1E-4 4	8.86489
36798.	117.33 7	122.75 3	34.273 5	.2066 2	-.3720 3	10.39941 9	.06E-4 4	8.86474
36802.	134.1 1	111.41 2	34.274 4	.2075 5	.2240 6	10.39916 6	.11E-4 3	8.86487
36806.	150.68 3	100.00 2	34.282 6	.2071 1	.82142 5	10.39932 3	.09E-4 3	8.86479
36810.	167.0 2	88.65 4	34.28 1	.2056 9	.4203 8	10.39949 8	.11E-4 3	8.86469

TABLE I
ORBITAL ACCELERATION, SATELLITE 1958 B1

Epoch (MJD)	Mean motion (n)	$n' \times 10^{-5}$	Epoch (MJD)	Mean motion (n)	$n' \times 10^{-5}$
36750.	10.39833	.68	36812.	10.39956	1.66
36752.	10.39836	.76	36814.	10.39942	1.34
36754.	10.39836	.89	36816.	10.39952	1.25
36756.	10.39840	.55	36818.	10.39959	1.37
36758.	10.39844	.56	36820.	10.39965	1.03
36760.	10.39846	.67	36822.	10.39968	.66
36762.	10.39848	.75	36824.	10.39971	.42
36764.	10.39849	.97	36826.	10.39987	.45
36766.	10.39855	1.24	36828.	10.39983	.18
36768.	10.39859	1.13	36830.	10.39982	.99
36770.	10.39867	.72	36832.	10.39985	.83
36772.	10.39873	.77	36834.	10.39989	.85
36774.	10.39872	.93	36836.	10.39993	1.17
36776.	10.39876	.88	36838.	10.39995	.99
36778.	10.39880	.93	36840.	10.40001	.64
36780.	10.39884	.99	36842.	10.40004	.90
36782.	10.39888	.80	36844.	10.40007	.90
36784.	10.39892	.96	36846.	10.40010	.50
36786.	10.39895	1.18	36848.	10.40010	.48
36788.	10.39900	.95	36850.	10.40014	1.10
36790.	10.39907	1.57	36852.	10.40013	.00
36792.	10.39914	1.57	36854.	10.40005	.40
36794.	10.39914	.36	36856.	10.40010	.69
36796.	10.3992	.00	36858.	10.40021	.93
36798.	10.39941	.59	36860.	10.40030	.49
36800.	10.39926	.89	36862.	10.40032	.23
36802.	10.39917	1.14	36864.	10.40033	.88
36804.	10.39927	1.76	36866.	10.40054	.54
36806.	10.39932	.94	36868.	10.40138	.59
36808.	10.39946	1.18	36870.	10.40145	.00
36810.	10.39949	1.06			

Satellite 1958 B2 (Vanguard I)

Carol A. Martin

I. SAO smoothed elements

The following elements are based on 215 observations and are valid for the period July 1 to July 31, 1959.

$$\begin{aligned}
 T_0 &= 36749.0 \text{ MJD} \\
 \omega &= 37^\circ 078 + 4^\circ 431t + ?19223 \times 10^{-4}t^2 + ?1214 \cos \omega \\
 \Omega &= -182^\circ 327 - 3^\circ 032t - ?1486 \times 10^{-4}t^2 + ?0123 \cos \omega \\
 i &= 34^\circ 236 - ?7 \times 10^{-2} \sin \omega \\
 e &= .18987 - .1058 \times 10^{-5}t + .5698 \times 10^{-3} \sin \omega \\
 M &= -.69293 + 10.74107t + .92 \times 10^{-5}t^2
 \end{aligned}$$

Standard error of one observation: $\sigma = \pm 4.7'$.

The following elements are based on 134 observations and are valid for the period August 1 to August 31, 1959.

$$\begin{aligned}
 T_0 &= 36780.0 \text{ MJD} \\
 \omega &= 174^\circ 010 + 4^\circ 421t + ?19223 \times 10^{-4}t^2 + ?1214 \cos \omega \\
 \Omega &= -275^\circ 973 - 3^\circ 030t - ?1486 \times 10^{-4}t^2 + ?0123 \cos \omega \\
 i &= 34^\circ 244 - ?7 \times 10^{-2} \sin \omega \\
 e &= .18966 - .1058 \times 10^{-5}t + .5698 \times 10^{-3} \sin \omega \\
 M &= -.71135 + 10.74154t + .45 \times 10^{-5}t^2
 \end{aligned}$$

Standard error of one observation: $\sigma = \pm 4.7'$.

Estimated date of demise: 2160.

II. SAO mean elements, derived from observations covering a period of 8 days, ± 4 days from epoch.

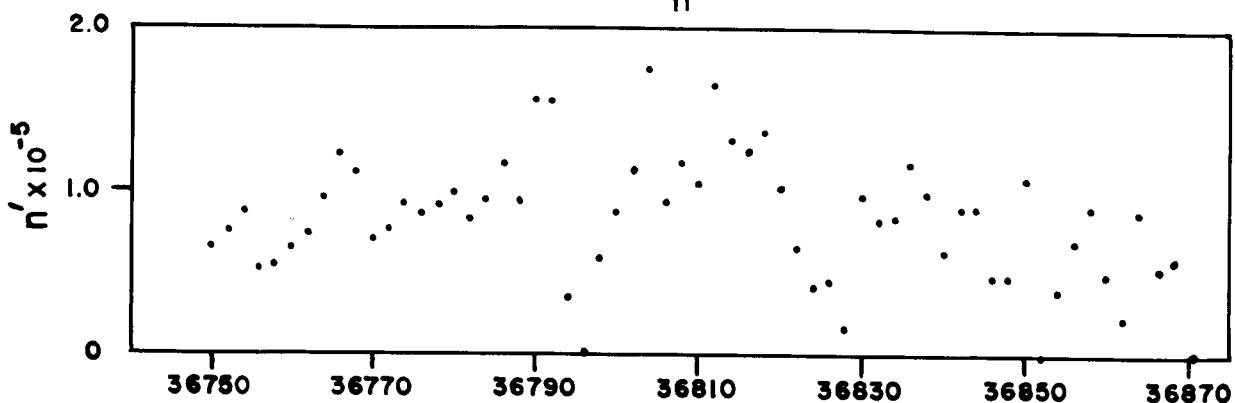
T (MJD)	ω	Ω	1	e	M	n	n'	a
36750.	41.611 4	-185.383 1	34.2428 4	.18973 1	.04793 1	10.741095 4	.099E-4 3	8.67568
36754.	59.271 4	-197.470 1	34.2428 5	.18971 1	.01252 1	10.741179 4	.073E-4 5	8.67563
36758.	76.921 4	-209.572 2	34.243 1	.18971 1	.97739 1	10.741204 5	.114E-4 5	8.67562
36762.	94.592 6	-221.662 3	34.239 1	.18973 2	.94244 2	10.741246 7	.149E-4 6	8.67560
36766.	112.184 9	-233.757 6	34.223 2	.18973 4	-.09205 3	10.741365 9	.095E-4 8	8.67553
36770.	129.82 1	-245.85 1	34.215 3	.18978 6	-.12627 5	10.74145 1	.06E-4 1	8.67549
36774.	147.444 2	-257.909 2	34.201 5	.18969 8	.83970 8	10.74151 2	.06E-4 2	8.67545
36778.	165.022 1	-268.101 3	34.216 4	.18972 9	.96597 9	10.74142 2	.08E-4 2	8.67546
36782.	192.60 1	-282.216 6	34.246 2	.18970 2	.75612 1	10.74163 2	.23E-4 1	8.67541
36786.	200.518 7	-294.165 3	34.258 2	.18969 2	.73803 2	10.74162 2	.107E-4 7	8.67540
36790.	218.22 2	-306.251 6	34.255 3	.18968 3	-.29561 5	10.74157 2	.09E-4 2	8.67543
36794.	235.90 2	-318.344 5	34.248 2	.18966 3	.67095 5	10.74168 2	.03E-4 2	8.67536
36798.	253.57 1	-330.460 6	34.239 2	.18969 4	-.36237 3	10.74178 3	.12E-4 2	8.67531
36802.	271.14 5	-342.69 2	34.201 5	.1897 2	-.3951 1	10.74206 5	.10E-4 4	8.67516
36806.	288.88 3	-354.65 1	34.261 3	.18955 8	-.42817 7	10.74167 3	.04E-4 2	8.67537
36810.	306.54 1	-366.723 4	34.244 1	.18991 4	-.46118 3	10.74181 1	.07E-4 1	8.67530

TABLE 2
ORBITAL ACCELERATION, SATELLITE 1958 82

Epoch (MJD)	Mean motion (n)	$n' \times 10^{-5}$	Epoch (MJD)	Mean motion (n)	$n' \times 10^{-5}$
36750.	10.74109	.99	36812.	10.74191	.70
36752.	10.74116	.82	36814.	10.74192	1.41
36754.	10.74118	.73	36816.	10.74195	1.37
36756.	10.74122	.22	36818.	10.74194	.54
36758.	10.74120	1.14	36820.	10.74199	.35
36760.	10.74127	1.00	36822.	10.74202	.47
36762.	10.74125	.15	36824.	10.74207	1.21
36764.	10.74134	1.23	36826.	10.74204	.03
36766.	10.74136	.95	36828.	10.74205	.52
36768.	10.74143	.86	36830.	10.74206	.60
36770.	10.74145	.61	36832.	10.74217	.42
36772.	10.74147	.90	36834.	10.74218	1.12
36774.	10.74151	.59	36836.	10.74224	2.23
36776.	10.74149	.63	36838.	10.74225	.16
36778.	10.74142	.78	36840.	10.74222	.60
36780.	10.74152	.56	36842.	10.74222	.29
36782.	10.74163	.23	36844.	10.74227	.79
36784.	10.74153	.27	36846.	10.74229	.61
36786.	10.74162	1.07	36848.	10.74237	.00
36788.	10.74162	.61	36850.	10.74234	.00
36790.	10.74157	.91	36852.	10.74232	.21
36792.	10.74164	.00	36854.	10.74233	.39
36794.	10.74168	.29	36856.	10.74235	.72
36796.	10.74175	.66	36858.	10.74232	.53
36798.	10.74178	1.24	36860.	10.74231	.21
36800.	10.74203	.00	36862.	10.74234	.29
36802.	10.74206	1.05	36864.	10.74236	.58
36804.	10.74183	.84	36866.	10.74237	.64
36806.	10.74167	.37	36868.	10.74238	.37
36808.	10.74177	.70	36870.	10.74239	.16
36810.	10.74181	.68			

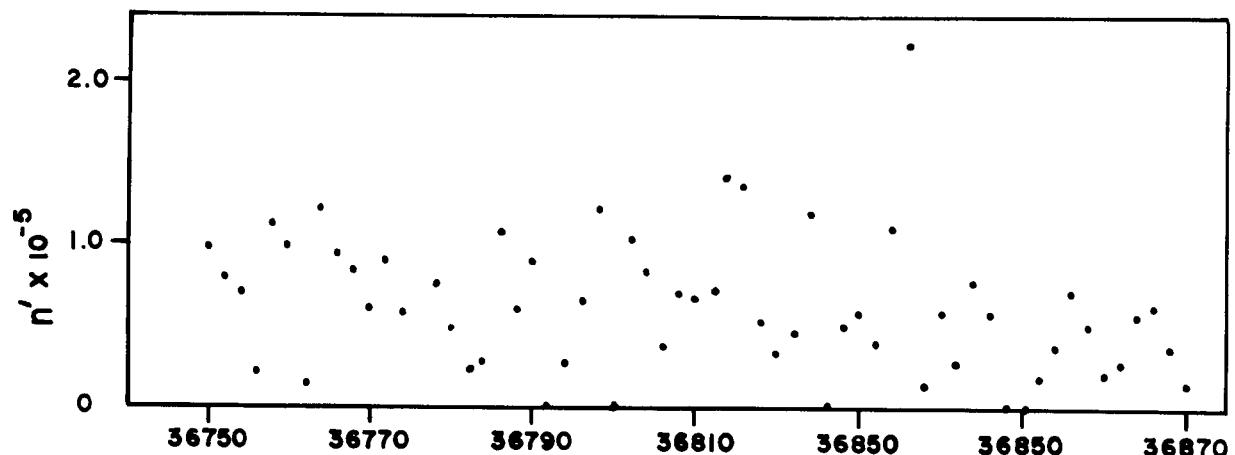
1958 BETA 1

n'



1958 BETA 2

n'



FIGURES 1 AND 2. - VARIATIONS IN THE ORBITAL ACCELERATION OF SATELLITES 1958 B1
AND B2 DURING THE PERIOD JULY THROUGH OCTOBER, 1959. TIME GIVEN IN MODIFIED
JULIAN DAYS. ACTUAL VALUES ARE GIVEN IN TABLES 1 AND 2.

SAO smoothed elements

In the following elements, an underline indicates an assumed value.

$$T_0 = 1959 \text{ July } 6.0 \text{ U.T.}$$

$$\omega = (257^\circ 35 \pm 90) - \underline{.40632t} - 9^\circ 1 \times 10^{-5} t^2$$

$$\Omega = (319^\circ 761 \pm .21) - (2^\circ 9380t \pm 41) - \underline{5^\circ 83} \times 10^{-4} t^2$$

$$i = (65^\circ 159 \pm 25)$$

$$e = (.06894 \pm 97) + (5. \pm 19) \times 10^{-5} t$$

$$M = (.7858 \pm 30) + (14.601589t \pm 39) + (1.0241 \pm 56) \times 10^{-3} t^2 + (1.81 \pm .27) \times 10^{-5} t^3$$

Valid for the period July 1.0 to 12.0. Standard error of one observation:

$$\sigma = \pm 15'.$$

$$T_0 = 1959 \text{ July } 17.0 \text{ U.T.}$$

$$\omega = \underline{253^\circ 9618} - \underline{.40832t} - 9^\circ 1 \times 10^{-5} t^2$$

$$\Omega = (287^\circ 287 \pm 18) - (2^\circ 9591t \pm 55) - \underline{5^\circ 83} \times 10^{-4} t^2$$

$$i = (65^\circ 151 \pm 12)$$

$$e = (.06916 \pm 21) - (.8 \pm 1.7) \times 10^{-4} t - 2.25 \times 10^{-7} t^2$$

$$M = (539268 \pm 38) + (14.628314t \pm 27) + (1.428 \pm 12) \times 10^{-3} t^2 - (2.61 \pm .22) \times 10^{-5} t^3$$

Valid for the period July 12.0 to 22.0. Standard error of one observation:

$$\sigma = \pm 6'.$$

$$T_0 = 1959 \text{ July } 27.0 \text{ U.T.}$$

$$\omega = (249^\circ 869 \pm 66) - \underline{.41014t} - 9^\circ 1 \times 10^{-5} t^2$$

$$\Omega = (257^\circ 6448 \pm 70) - (2^\circ 9728t \pm 28) - \underline{5^\circ 83} \times 10^{-4} t^2$$

$$i = (65^\circ 1518 \pm 94)$$

$$e = (.06822 \pm 17) - (.62 \pm .57) \times 10^{-5} t - 2.25 \times 10^{-7} t^2$$

$$M = (.94870 \pm 22) + (14.653206t \pm 14) + (1.2047t^2 \pm 31) - (8.58 \pm .69) \times 10^{-6} t^3$$

Valid for the period July 22.0 to 32.0. Standard error of one observation:

$$\sigma = \pm 10'.$$

$$T_0 = 1959 \text{ Aug. } 6.0 \text{ U.T.}$$

$$\omega = (246^\circ 015 \pm 54) - \underline{.41196t} - 9^\circ 1 \times 10^{-5} t^2$$

$$\Omega = (227^\circ 8586 \pm 30) - (2^\circ 9827t \pm 12) - \underline{5^\circ 83} \times 10^{-4} t^2$$

$$i = (65^\circ 1382 \pm 51)$$

$$e = (.067632 \pm 64) - (1.31 \pm .27) \times 10^{-4} t - 2.25 \times 10^{-7} t^2$$

$$M = (.59723 \pm 17) + (14.677086t \pm 8) + (1.2633 \pm 16) \times 10^{-3} t^2 + (4.18 \pm .31) \times 10^{-6} t^3$$

Valid for the period Aug. 1.0 to 11.0. Standard error of one observation:

$$\sigma = \pm 4'.$$

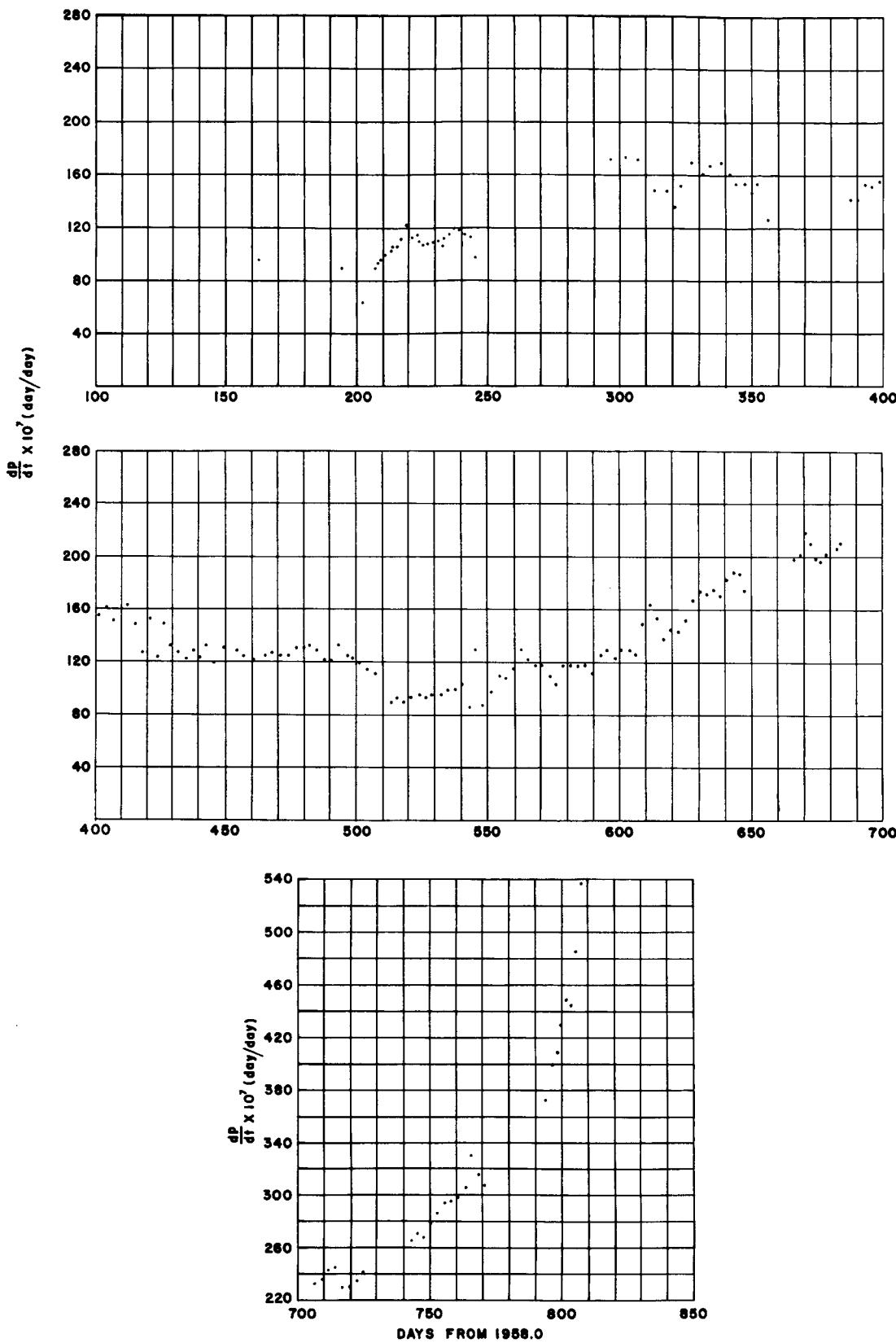


FIGURE 3. - VARIATIONS IN ORBITAL ACCELERATION OF SATELLITE 1958 δ2.

$$\begin{aligned}
T_0 &= 1959 \text{ Aug. } 13.0 \text{ U.T.} \\
\omega &= 243^\circ 1268 - 413234t - 9^\circ 1 \times 10^{-5} t^2 \\
\Omega &= (207^\circ 0044 \pm 53) - (2^\circ 98552t \pm 78) - 5^\circ 83 \times 10^{-4} t^2 \\
i &= (65^\circ 1386 \pm 28) \\
e &= (.066559 \pm 52) - 1.341 \times 10^{-4} t - 2.25 \times 10^{-7} t^2 \\
M &= (.399181 \pm 17) + (14.694827t \pm 4) + (1.24880t^2 \pm 30) - (1.626 \pm 63) \times 10^{-6} t^3
\end{aligned}$$

Valid for the period Aug. 11.0 to 18.0. Standard error of one observation:
 $\sigma = \pm 7'$.

$$\begin{aligned}
T_0 &= 1959 \text{ Aug. } 22.0 \text{ U.T.} \\
\omega &= 239^\circ 400 - 41487t - 9^\circ 1 \times 10^{-5} t^2 \\
\Omega &= (180^\circ 1080 \pm 69) - (3^\circ 0005t \pm 13) - 5^\circ 83 \times 10^{-4} t^2 \\
i &= (65^\circ 1214 \pm 24) \\
e &= (.065532 \pm 56) - 1.3815 \times 10^{-4} t - 2.25 \times 10^{-7} t^2 \\
M &= (.759629 \pm 17) + (14.719096t \pm 4) + (1.3763 \pm 10) \times 10^{-3} t^2 + (1.267 \pm 35) \times 10^{-5} t^3
\end{aligned}$$

Valid for the period Aug. 18.0 to 32.0. Standard error of one observation:
 $\sigma = \pm 6'$. Subsequent to 13 August, observations used were principally from Meudon and Jokionien Observatories.

Date of demise: April 6, 1960.

Table 3 shows the nodal periods and their variations during the lifetime of Satellite 1958 82. The variations are also shown in graphical form in Figure 3.

In Table 3 the time (T) is counted from 1958.0 in days; the year/days begin in June, 1958, and end in March, 1960. The period is in minutes, and \dot{P} is in days/day. $\dot{P} \times 10^7$ is given in place of \dot{P} .

\dot{P} is computed by numerical differentiation of the nodal passage time derived from the SAO Sub-Satellite Program, except for the months of October and November, 1959. For this period \dot{P} is computed by the SAO Differential Orbit Improvement Program.

From the launching time, 15 May 1958, through October 1958, there are not sufficient observations in good distribution to derive the value of \dot{P} at regular intervals of time. There are also some gaps in the observations from time to time because of lack of visibility.

Dr. P. E. Zadunaisky (see page 24) is now analyzing the data for this period, and has kindly furnished some of his values already derived for the graph shown in Figure 3.

TABLE 3

VARIATIONS OF NODAL PERIOD OF SATELLITE 1958 82

T (yr/days)	Period (minutes)	$\frac{dP}{dt} \times 10^7$ (days/day)	T (yr/days)	Period (minutes)	$\frac{dP}{dt} \times 10^7$ (days/day)	T (yr/days)	Period (minutes)	$\frac{dP}{dt} \times 10^7$ (days/day)
162.3	105.626	-96				465.8	100.021	-126
194.3	105.252	-90	387.4	101.600	-142	468.6	99.970	-128
202.0	105.164	-64	390.2	101.543	-142	471.3	99.919	-126
207.8	105.095	-94	393.0	101.483	-154	474.1	99.869	-126
210.8	105.054	-100	395.9	101.422	-152	476.9	99.817	-132
213.7	105.011	-106	398.7	101.361	-156	479.7	99.765	-132
223.9	104.847	-110	401.5	101.297	-156	482.4	99.712	-134
232.6	104.710	-106	404.3	101.232	-162	485.2	99.659	-130
237.0	104.638	-120	407.1	101.169	-152	488.0	99.610	-122
245.7	104.496	-98	409.9	101.105	-162	490.7	99.562	-122
296.3	103.559	-172	412.7	101.039	-164	493.5	99.509	-134
302.0	103.424	-174	415.5	100.976	-150	496.3	99.457	-126
307.0	103.302	-172	418.3	100.920	-128	499.0	99.407	-124
313.5	103.156	-148	421.1	100.863	-154	501.8	99.358	-120
317.8	103.062	-148	423.9	100.810	-124	504.5	99.311	-116
320.6	103.004	-136	426.7	100.751	-150	507.3	99.266	-112
323.5	102.945	-152	429.5	100.694	-134	510.1	99.222	-112
327.8	102.849	-170	432.3	100.641	-128	512.8	99.182	-90
331.4	102.759	-160	435.1	100.591	-122	515.6	99.145	-94
334.9	102.670	-168	437.9	100.540	-130	518.3	99.109	-90
338.5	102.582	-170	440.7	100.489	-124	521.1	99.073	-94
341.3	102.515	-160	443.5	100.437	-134	523.8	99.035	-96
344.2	102.450	-154	446.3	100.383	-120	526.6	98.997	-94
347.0	102.388	-154	449.1	100.336	-132	529.3	98.960	-96
349.9	102.324	-146	451.9	100.278	-160	532.1	98.922	-96
352.0	102.277	-154	454.7	100.220	-130	534.8	98.884	-100
357.0	102.179	-126	457.4	100.168	-126	537.6	98.844	-100
			460.2	100.118	-122	540.3	98.804	-104
			463.0	100.070	-120	543.1	98.766	-86

VARIATIONS OF NODAL PERIOD OF SATELLITE 1958 82 (concluded)

T (yr/days)	Period (minutes)	$\frac{dP}{dt} \times 10^7$ (days/day)	T (yr/days)	Period (minutes)	$\frac{dP}{dt} \times 10^7$ (days/day)	T (yr/days)	Period (minutes)	$\frac{dP}{dt} \times 10^7$ (days/day)
545.8	98.724	-130	624.8	97.309	-152	716.8	94.605	-230
548.5	98.675	-88	627.5	97.246	-168	719.4	94.518	-231
551.3	98.639	-98	630.2	97.180	-174	722.1	94.430	-235
554.0	98.598	-110	632.9	97.112	-172	724.7	94.339	-242
556.8	98.555	-108	635.6	97.044	-176			
559.5	98.510	-116	637.0	97.000	-171			
562.2	98.462	-130	639.0	96.950	-180	742.4	93.669	-266
565.0	98.413	-122	641.0	96.898	-183	745.0	93.569	-271
567.7	98.367	-110	643.0	96.844	-190	747.6	93.468	-268
570.4	98.323	-118	645.0	96.790	-188	750.2	93.366	-279
573.2	98.278	-112	647.0	96.737	-175	752.8	93.260	-287
579.9	98.236	-104				755.4	93.152	-294
578.6	98.193	-118				758.0	93.042	-296
581.3	98.148	-118				760.6	92.932	-299
584.1	98.102	-118				763.2	92.819	-307
586.8	98.055	-118				765.7	92.701	-331
589.5	98.011	-112	668.0	96.148	-200			
592.2	97.964	-126	670.0	96.087	-201	768.3	92.581	-316
595.0	97.914	-130	672.0	96.025	-219	770.9	92.466	-308
597.7	97.864	-124	674.0	95.965	-212			
600.4	97.814	-130	676.0	95.909	-200			
603.1	97.763	-130	678.0	95.851	-198			
605.8	97.713	-126	680.0	95.792	-203	793.9	91.374	-351
608.5	97.659	-150	682.5	95.718	-204	795.8	91.273	-380
611.3	97.598	-164				797.7	91.168	-389
614.0	97.536	-154						
616.7	97.479	-138						
619.4	97.423	-146						
622.1	97.367	-144						

Table 4 gives the perigee distance of Satellite 1958 62 from May, 1958 to March, 1960. Time is given in Modified Julian Days. Units are expressed in earth equatorial radii.

TABLE 4
PERIGEE DISTANCE OF SATELLITE 1958 62

T	q	T	q	T	q
36340	1.0338	36605	1.0315	36925	1.0290
36400	1.0330	36650	1.0310	36950	1.0288
36495	1.0325	36770	1.0306	36970	1.0285
36525	1.0320	36840	1.0301	37000	1.0275
36550	1.0318	36870	1.0297		

Table 5 gives the relative positions of the sun and of the perigee of Satellite 1958 62 during the course of its lifetime, as computed by Y. Kozai, by use of the machine program written by P. E. Zadunaisky (see page 24). The time T is given in Modified Julian Days, ψ is the geocentric angular distance from the sun to satellite perigee, ϕ is the latitude of perigee, and C is the correction of perigee height, in kilometers.

TABLE 5
RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1958 62

T (MJD)	ω	Ω	ψ	$\Delta\alpha$	ϕ	C (km)
36280.	74.25	152.57	115.70	211.53	60.87	16.4
36285.	73.16	140.99	118.06	193.49	60.31	16.2
36290.	72.02	129.33	117.50	175.37	59.69	16.0
36295.	70.82	117.61	113.80	157.17	59.01	15.8
36300.	69.57	105.83	107.25	138.88	58.27	15.5
36305.	68.27	93.98	98.44	120.52	57.47	15.3
36310.	66.92	82.07	88.00	102.08	56.61	15.0
36315.	65.53	70.10	76.54	83.57	55.70	14.7
36320.	64.09	58.07	64.57	64.98	54.72	14.3
36325.	62.60	45.98	52.74	46.32	53.69	13.9
36330.	61.08	33.84	42.02	27.59	52.60	13.6
36335.	59.51	21.64	34.22	8.80	51.45	13.1
36340.	57.91	9.38	32.11	349.93	50.26	12.7
36345.	56.28	357.08	36.93	331.00	49.01	12.2
36350.	54.61	344.72	46.60	312.01	47.72	11.8
36355.	52.90	332.31	58.64	292.98	46.38	11.3
36360.	51.17	319.85	71.59	273.90	44.99	10.7
36365.	49.41	307.34	84.56	254.79	43.57	10.2

TABLE 5

RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1958 82 (Continued)

T (MJD)	ω	Ω	ψ	$\Delta\alpha$	ϕ	C (km)
36370.	47.63	294.79	96.83	235.65	42.11	9.7
36375.	45.82	282.19	107.51	216.51	40.61	9.1
36380.	43.99	269.54	115.46	197.36	39.07	8.5
36385.	42.14	256.86	119.30	178.23	37.51	8.0
36390.	40.27	244.13	118.08	159.12	35.92	7.4
36395.	38.39	231.36	111.92	140.05	34.30	6.8
36400.	36.49	218.55	101.88	121.01	32.66	6.3
36405.	34.57	205.71	89.19	102.03	31.00	5.7
36410.	32.65	192.82	74.75	83.10	29.32	5.1
36415.	30.72	179.91	59.19	64.22	27.62	4.6
36420.	28.78	166.96	42.91	45.41	25.91	4.1
36425.	26.84	153.97	26.36	26.65	24.19	3.6
36430.	24.90	140.95	11.11	7.94	22.46	3.1
36435.	22.95	127.91	13.02	34.9.28	20.72	2.7
36440.	21.00	114.83	29.39	330.67	18.98	2.3
36445.	19.06	101.73	47.19	312.09	17.24	1.9
36450.	17.13	88.60	65.40	293.54	15.50	1.5
36455.	15.19	75.44	83.82	275.01	13.76	1.2
36460.	13.27	62.26	102.39	256.49	12.03	0.9
36465.	11.36	49.06	121.07	237.97	10.30	0.7
36470.	9.46	35.83	139.83	219.43	8.58	0.5
36475.	7.58	22.59	158.65	200.88	6.87	0.3
36480.	5.71	9.33	177.45	182.30	5.18	0.2
36485.	3.86	356.05	163.55	163.68	3.50	0.1
36490.	2.03	342.75	144.63	145.00	1.84	0.0
36495.	0.22	329.43	125.71	126.27	0.20	0.0
36500.	359.45	316.11	107.43	107.90	-0.49	0.0
36505.	357.52	302.83	88.52	89.01	-2.25	0.0
36510.	355.59	289.51	69.65	70.00	-4.00	0.1
36515.	353.65	276.16	50.90	50.87	-5.76	0.2
36520.	351.72	262.78	32.46	31.62	-7.51	0.4
36525.	349.79	249.37	15.38	12.25	-9.25	0.6
36530.	347.86	235.92	11.54	352.74	-11.00	0.8
36535.	345.93	222.45	27.01	333.12	-12.74	1.0
36540.	344.00	208.94	44.75	313.37	-14.48	1.3
36545.	342.07	195.40	62.54	293.52	-16.22	1.7
36550.	340.14	181.83	79.90	273.57	-17.96	2.0
36555.	338.21	168.23	96.40	253.53	-19.69	2.4
36560.	336.28	154.60	111.33	233.42	-21.41	2.9
36565.	334.34	140.93	123.40	213.26	-23.14	3.3
36570.	332.41	127.24	130.49	193.06	-24.85	3.8
36575.	330.47	113.51	130.45	172.84	-26.57	4.3
36580.	328.54	99.75	123.37	152.60	-28.27	4.8
36585.	326.60	85.97	111.51	132.35	-29.97	5.4

TABLE 5
RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1958 82 (Continued)

T (MJD)	ω	Ω	ψ	$\Delta\alpha$	ϕ	C (km)
36590.	324.66	72.15	97.04	112.11	-31.67	5.9
36595.	322.71	58.30	81.35	91.88	-33.35	6.5
36600.	320.77	44.42	65.33	71.65	-35.03	7.1
36605.	318.82	30.51	49.86	51.42	-36.69	7.7
36610.	316.87	16.57	36.52	31.19	-38.35	8.3
36615.	314.92	2.60	28.98	10.95	-39.99	8.9
36620.	312.96	348.60	31.78	350.69	-41.61	9.5
36625.	311.00	334.57	42.81	330.39	-43.22	10.1
36630.	309.04	320.51	57.26	310.03	-44.82	10.7
36635.	307.07	306.42	72.73	289.60	-46.39	11.3
36640.	305.10	292.30	88.16	269.08	-47.94	11.8
36645.	303.13	278.15	102.77	248.45	-49.46	12.4
36650.	301.15	263.97	115.65	227.68	-50.95	13.0
36655.	299.17	249.76	125.47	206.75	-52.41	13.5
36660.	297.18	235.52	130.51	185.65	-53.83	14.0
36665.	295.19	221.25	129.68	164.33	-55.20	14.5
36670.	293.19	206.96	123.74	142.79	-56.52	14.9
36675.	291.19	192.63	114.77	120.99	-57.79	15.4
36680.	289.18	178.27	104.74	98.91	-58.99	15.8
36685.	287.17	163.89	95.16	76.53	-60.11	16.1
36690.	285.15	149.47	87.31	53.84	-61.15	16.5
36695.	283.13	135.03	82.32	30.83	-62.10	16.8
36700.	280.97	120.60	81.07	7.25	-62.98	17.0
36705.	278.91	106.07	83.80	343.51	-63.70	17.3
36710.	276.86	91.53	90.07	319.50	-64.28	17.4
36715.	274.81	76.97	98.97	295.26	-64.72	17.6
36720.	272.77	62.39	109.43	270.83	-65.00	17.6
36725.	270.73	47.80	120.28	246.28	-65.14	17.7
36730.	268.69	33.19	130.10	221.65	-65.11	17.7
36735.	266.65	18.55	136.93	197.02	-64.94	17.6
36740.	264.62	3.90	138.54	172.46	-64.61	17.5
36745.	262.58	349.22	134.18	148.01	-64.13	17.4
36750.	260.55	334.52	125.44	123.73	-63.52	17.2
36755.	258.51	319.80	114.53	99.65	-62.77	17.0
36760.	256.48	305.05	103.12	75.81	-61.91	16.7
36765.	254.45	290.27	92.52	52.21	-60.94	16.4
36770.	252.41	275.47	83.92	28.87	-59.88	16.1
36775.	250.38	260.64	78.52	5.79	-58.72	15.7
36780.	248.34	245.79	77.32	342.95	-57.49	15.3
36785.	246.30	230.90	80.62	320.35	-56.18	14.8
36790.	244.25	215.98	87.90	297.97	-54.81	14.3
36795.	242.20	201.03	98.09	275.79	-53.38	13.8
36800.	240.15	186.05	109.99	253.80	-51.90	13.3
36805.	238.10	171.04	122.26	231.97	-50.38	12.7

TABLE 5
RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1958 82 (Concluded)

T (MJD)	ω	Ω	ψ	$\Delta\alpha$	ϕ	C (km)
36810.	236.04	155.99	133.11	210.29	-48.81	12.2
36815.	233.97	140.91	139.65	188.73	-47.20	11.6
36820.	231.90	125.79	138.62	167.27	-45.56	10.9
36825.	229.82	110.64	129.88	145.89	-43.89	10.3
36830.	227.74	95.44	116.24	124.58	-42.18	9.7
36835.	225.55	80.21	100.03	103.30	-40.45	9.0
36840.	223.55	64.94	82.52	82.04	-38.69	8.4
36845.	221.45	49.63	64.48	60.79	-36.91	7.7
36850.	220.25	69.78	74.91	75.62	-35.88	7.4
36855.	217.90	49.41	52.17	49.17	-33.87	6.7
36860.	215.58	29.47	30.91	23.19	-31.86	6.0
36865.	213.29	9.95	18.58	357.65	-29.86	5.3
36870.	211.02	350.82	29.58	332.48	-27.87	4.7
36875.	208.78	332.05	50.01	307.65	-25.90	4.1
36880.	206.55	313.62	71.76	283.12	-23.92	3.5
36885.	204.34	295.49	93.27	258.86	-21.96	3.0
36890.	202.15	277.64	113.61	234.82	-20.00	2.5
36895.	199.96	260.05	131.20	210.98	-18.04	2.1
36900.	197.79	242.69	142.09	187.32	-16.09	1.6
36905.	195.61	225.52	140.56	163.80	-14.13	1.3
36910.	193.44	208.53	127.89	140.40	-12.17	1.0
36915.	191.27	191.69	110.07	117.12	-10.21	0.7
36920.	189.09	174.97	90.31	93.93	-8.24	0.4
36925.	186.91	158.34	69.94	70.82	-6.27	0.3
36930.	184.72	141.77	49.84	47.77	-4.28	0.1
36935.	182.51	125.25	31.74	24.78	-2.28	0.0
36940.	180.29	108.74	22.33	1.84	-0.26	0.0
36945.	178.05	92.22	31.33	338.91	1.77	0.0
36950.	175.79	75.65	49.73	316.00	3.82	0.1
36955.	173.50	59.02	70.64	293.08	5.89	0.2
36960.	171.19	42.29	92.45	270.12	7.99	0.4
36965.	168.85	25.44	114.71	247.10	10.11	0.7
36970.	166.47	8.44	137.25	223.99	12.25	1.0
36975.	164.06	351.27	159.90	200.76	14.43	1.3
36980.	161.61	333.90	175.35	177.36	16.63	1.8
36985.	159.11	316.30	153.50	153.77	18.87	2.2
36990.	156.58	298.44	130.43	129.94	21.13	2.8
36995.	153.99	280.30	107.37	105.82	23.43	3.4
37000.	151.36	261.85	84.62	81.38	25.77	4.1
37005.	148.67	243.07	62.80	56.56	28.14	4.8
37010.	145.93	223.92	43.70	31.31	30.54	5.5
37015.	143.12	204.39	32.85	5.58	32.98	6.4
37020.	140.26	184.44	38.10	339.31	35.44	7.2

SAO smoothed elements

The following elements are based on 76 observations and are valid from June 26 through July 25, 1959.

$$\begin{aligned}T_0 &= 36757.53351 \text{ MJD} \\ \omega &= (157.175 \pm 13) + (5.2662 \pm 10)t + .728 \times 10^{-4} t^2 + .14 \cos \omega \\ \Omega &= (49.106 \pm 6) - (3.5046 \pm 6)t - .484 \times 10^{-4} t^2 + .012 \cos \omega \\ i &= (32.983 \pm 2) - .006 \sin \omega \\ e &= (.16535 \pm 6) - .2306 \times 10^{-5} t + .424 \times 10^{-3} \sin \omega \\ M &= (.861224 \pm 33) + (11.456388 \pm 3)t + (.2581 \pm 8) \times 10^{-4} t^2\end{aligned}$$

Standard error of one observation: $\sigma = \pm 9.0'$.

The following elements are based on 85 observations and are valid from July 26 through August 25, 1959.

$$\begin{aligned}T_0 &= 36788.0 \text{ MJD} \\ \omega &= (317.700 \pm 20) + (5.2764 \pm 18)t + .728 \times 10^{-4} t^2 + .14 \cos \omega \\ \Omega &= (302.257 \pm 7) - (3.5082 \pm 10)t - .484 \times 10^{-4} t^2 + .013 \cos \omega \\ i &= (32.874 \pm 2) - .006 \sin \omega \\ e &= (.16529 \pm 3) - .7874 \times 10^{-5} t + .424 \times 10^{-3} \sin \omega \\ M &= (.918055 \pm 41) + (11.457589 \pm 4)t + (1612 \pm 9) \times 10^{-4} t^2\end{aligned}$$

Standard error of one observation: $\sigma = \pm 10'$.

Estimated date of demise: 1986.

SAO smoothed elements

The following elements are based on 98 observations and are valid from June 26 through July 25, 1959.

$$\begin{aligned}T_0 &= 36755.45723 \text{ MJD} \\ \omega &= (100^\circ 6480 \pm 75) + (4^\circ 9294 \pm 12)t + .766 \times 10^{-4} t^2 + .124 \cos \omega \\ \Omega &= (86^\circ 880 \pm 6) - (3^\circ 284 \pm 1)t + .509 \times 10^{-4} t^2 + .013 \cos \omega \\ i &= (32^\circ 933 \pm 2) - .006 \sin \omega \\ e &= (.18373 \pm 7) - .8802 \times 10^{-5} t + .406 \times 10^{-3} \sin \omega \\ M &= (.020532 \pm 15) + (11.081234 \pm 4)t + (.3175 \pm 10) \times 10^{-4} t^2\end{aligned}$$

Standard error of one observation: $\sigma = \pm 9.0'$.

The following elements are based on 101 observations and are valid from July 26 through August 25, 1959.

$$\begin{aligned}T_0 &= 36788.0 \text{ MJD} \\ \omega &= (261^\circ 256 \pm 16) + (4^\circ 9357 \pm 12)t + .766 \times 10^{-4} t^2 + .124 \cos \omega \\ \Omega &= (339^\circ 970 \pm 7) - (3^\circ 2877 \pm 7)t - .509 \times 10^{-4} t^2 + .013 \cos \omega \\ i &= (32^\circ 921 \pm 3) - .006 \sin \omega \\ e &= (.18379 \pm 5) - .8802 \times 10^{-5} t + .406 \times 10^{-3} \sin \omega \\ M &= (.665524 \pm 28) + (11.082963 \pm 2)t + (.1863 \pm 7) \times 10^{-4} t^2\end{aligned}$$

Standard error of one observation: $\sigma = \pm 13'$.

Estimated date of demise: 1999.

ORBITAL ELEMENTS FOR SATELLITE 1958 GAMMA

by

Imre G. Izsak¹

The SAO smoothed elements for Satellite 1958 Gamma (Explorer III) were obtained by a least-squares fit to the SAO mean elements.

As can be seen from Figures 4 and 5, the variations in the mean motion have a very complicated nature. Different factors are responsible for these "irregularities" -- the tumbling of the satellite, the variation of the height of perigee above the earth-ellipsoid, the variation of the geocentric angular distance between the sun and the satellite's perigee, the fluctuations in solar activity, and perhaps others. All these variations produce changes in the air drag near perigee. At the present time it seems to be very difficult, if not impossible, to separate these effects. Note also that these effects on the mean motion produce indirect perturbations of the elements ω , Ω and e . Consequently, the long-periodic gravitational effects due to the third harmonic in the potential of the earth are completely masked by the variations of atmospheric origin. In the table of the SAO mean elements, values have not been computed for certain epochs.

Under the circumstances mentioned, the following standard deviations σ of the least-squares fit represent a measure of indirect atmospheric effects on the elements rather than errors in the determination of the elements:

$$\sigma(\omega) = \pm 0^{\circ}49, \quad \sigma(\Omega) = \pm 0^{\circ}087, \quad \sigma(i) = \pm 0^{\circ}033, \quad \sigma(e) = \pm 0^{\circ}0011 .$$

Satellite 1958 Gamma (Explorer III)

I. SAO smoothed elements

The following elements are based on 776 observations and are valid for the period March 29 to June 15, 1958.

$$\begin{aligned} T_0 &= 1958 \text{ May } 7.0 \text{ U.T.} \\ \omega &= 370^{\circ}30 + 7^{\circ}3582t + 1^{\circ}8109 \times 10^{-2}t^2 + 1^{\circ}088 \times 10^{-4}t^3 \\ \Omega &= 55^{\circ}73 - 4^{\circ}9470t - 1^{\circ}2040 \times 10^{-2}t^2 - 0^{\circ}653 \times 10^{-4}t^3 \\ i &= 33^{\circ}333 - 3^{\circ}4 \times 10^{-4}t \\ e &= 0.12094 - 1.3160 \times 10^{-3}t - 5.837 \times 10^{-6}t^2 \\ M &= 504.86200 + 13.470043t + 1.556036 \times 10^{-2}t^2 + 5.01826 \times 10^{-5}t^3 \end{aligned}$$

Date of demise: June 28, 1958.

¹ Astronomer, Smithsonian Astrophysical Observatory.

II. SAO mean elements, derived from observations covering a period of 5 days, \pm 2.5 days from epoch.

T (MJD)	ω	Ω	i	e	M	n	n'	Δ
36291.	104.82	239.98	33.402	.16340	.20497	12.46462	.901E-2	7.85596
36292.	110.97	229.85	33.388	.16321	12.67832	12.48313	.977E-2	7.84819
36293.	117.56	225.67	33.364	.16249	25.17048	12.50286	1.001E-2	7.83993
36294.	124.03	221.28	33.368	.16149	37.68428	12.52484	1.098E-2	7.83075
36295.	130.19	217.01	33.347	.16099	50.22225	12.54992	1.244E-2	7.82031
36296.	136.66	212.63	33.359	.15931	62.78464	12.57476	1.260E-2	7.81000
36297.	143.12	208.25	33.352	.15869	75.37216	12.60038	1.297E-2	7.79940
36298.	149.79	203.84	33.345	.15770	87.98522	12.62662	1.324E-2	7.78859
36299.	156.22	199.50	33.342	.15652	100.62513	12.65330	1.358E-2	7.77764
36300.								
36301.	169.89	190.76	33.305	.15411	125.98541	12.70780	1.376E-2	7.75537
36302.	176.20	186.28	33.289	.15290	138.70730	12.73528	1.434E-2	7.74421
36303.	182.94	181.84	33.290	.15237	151.45668	12.76399	1.444E-2	7.73259
36304.								
36305.	195.32	172.86	33.298	.14748	177.04092	12.81336	1.151E-2	7.71271
36306.	202.73	168.40	33.351	.14714	189.86212	12.83685	1.258E-2	7.70330
36307.	209.45	163.99	33.358	.14701	202.71119	12.86218	1.291E-2	7.69318
36308.	215.94	159.49	33.357	.14572	215.58683	12.88828	1.323E-2	7.68278
36309.	221.84	155.00	33.332	.14537	228.49159	12.91194	1.124E-2	7.67339
36310.	229.00	150.36	33.365	.14335	241.41467	12.93453	1.064E-2	7.66445
36311.	235.65	145.86	33.360	.14236	254.36018	12.95627	1.086E-2	7.65587
36312.	242.70	141.21	33.350	.14172	267.32621	12.97862	1.186E-2	7.64708
36313.	249.71	136.62	33.367	.14054	280.31608	13.00237	1.203E-2	7.63776
36314.	256.06	132.04	33.348	.14015	293.33325	13.02603	1.137E-2	7.62850
36315.	263.12	127.42	33.360	.13924	306.37110	13.04859	1.016E-2	7.61971
36316.	270.53	122.74	33.380	.13732	319.42899	13.06915	.974E-2	7.61171
36317.	277.63	118.02	33.386	.13634	332.50701	13.08894	1.039E-2	7.60403
36318.	285.46	113.44	33.299	.13537	345.60303	13.11091	1.128E-2	7.59553
36319.	291.337	108.72	33.255	.13556	358.72790	13.13451	1.275E-2	7.58642
36320.	298.624	104.04	33.276	.13394	371.87448	13.16069	1.324E-2	7.57635
36321.	305.78	99.37	33.245	.13337	385.04744	13.18787	1.382E-2	7.56594
36322.	311.73	94.62	33.328	.13222	398.25384	13.21497	1.305E-2	7.55559
36323.	319.88	89.83	33.322	.13018	411.47958	13.24118	1.242E-2	7.54561
36324.	326.95	85.04	33.339	.12845	424.73302	13.26659	1.303E-2	7.53597
36325.								
36326.	341.44	75.21	33.292	.12740	451.31826	13.32236	1.550E-2	7.51491
36327.	349.04	70.33	33.322	.12582	464.65480	13.35370	1.604E-2	7.50315
36328.	355.97	65.54	33.321	.12439	478.02540	13.38617	1.634E-2	7.49101
36329.	362.56	60.62	33.319	.12431	491.43108	13.41830	1.580E-2	7.47904
36330.	371.27	55.69	33.345	.12270	504.86200	13.44858	1.454E-2	7.46780
36331.	378.33	50.75	33.344	.12132	518.32623	13.47794	1.451E-2	7.45695
36332.	385.73	45.77	33.344	.12000	531.81876	13.50713	1.468E-2	7.44620
36333.	394.23	40.85	33.384	.11942	545.33696	13.53965	1.678E-2	7.43427
36334.								

T (MJD)	ω	Ω	i	e	M	n	n'	a
36335.	407.66	30.68	33.314	.11534	572.49083	13.61349	1.972E-2	7.40735
36336.	415.22	25.57	33.335	.11344	586.12421	13.65307	1.989E-2	7.39302
36337.	422.91	20.48	33.342	.11161	599.79705	13.69304	1.999E-2	7.37863
36338.	430.96	15.49	33.335	.10982	613.50683	13.72994	1.908E-2	7.36539
36339.	438.05	10.17	33.322	.10736	627.25803	13.76486	1.748E-2	7.35292
36340.	445.61	5.05	33.344	.10615	641.04053	13.79736	1.639E-2	7.34137
36341.	453.51	-23	33.344	.10676	654.85030	13.82559	1.547E-2	7.33137
36342.	461.46	-5.47	33.340	.10538	668.69101	13.85681	1.573E-2	7.32035
36343.	469.30	-10.71	33.335	.10303	682.56365	13.89078	1.712E-2	7.30841
36344.	478.11	-15.85	33.270	.10127	696.46729	13.92628	1.857E-2	7.29597
36345.								
36346.	492.73	-26.75	33.329	.09863	724.39970	14.00458	2.042E-2	7.26874
36347.	500.83	-32.10	33.331	.09673	738.42488	14.04703	2.121E-2	7.25409
36348.	508.90	-37.51	33.308	.09481	752.49300	14.08976	2.151E-2	7.23941
36349.	516.93	-43.02	33.318	.09299	766.60478	14.13325	2.179E-2	7.22454
36350.	524.77	-48.57	33.323	.09066	780.76100	14.17679	2.180E-2	7.20974
36351.	532.71	-54.14	33.336	.08884	794.96073	14.22042	2.179E-2	7.19498
36352.								
36353.	550.03	-65.22	33.326	.08598	823.48346	14.30293	2.048E-2	7.16727
36354.	558.40	-70.87	33.327	.08433	837.80682	14.34370	2.053E-2	7.15367
36355.	567.08	-76.58	33.347	.08226	852.16386	14.37711	1.853E-2	7.14258
36356.								
36357.								
36358.	593.41	-93.64	33.400	.07843	895.45155	14.47922	1.626E-2	7.10896
36359.	601.50	-99.59	33.333	.07718	909.94918	14.51073	1.564E-2	7.09865
36360.	610.40	-105.411	33.345	.07550	924.47510	14.54222	1.578E-2	7.08840
36361.								
36362.	627.90	-117.11	33.347	.07294	953.62533	14.61003	1.754E-2	7.06643
36363.	636.87	-123.09	33.292	.07158	968.25224	14.64589	1.821E-2	7.05488
36364.								
36365.								
36366.	664.60	-140.83	33.341	.06768	1012.35603	14.76410	2.117E-2	7.01716
36367.	672.12	-146.98	33.369	.06584	1027.14645	14.80868	2.239E-2	7.00307
36368.	681.56	-153.03	33.307	.06353	1041.97632	14.85469	2.322E-2	6.98859
36369.	692.32	-159.60	33.239	.06102	1056.85376	14.90603	2.492E-2	6.97252

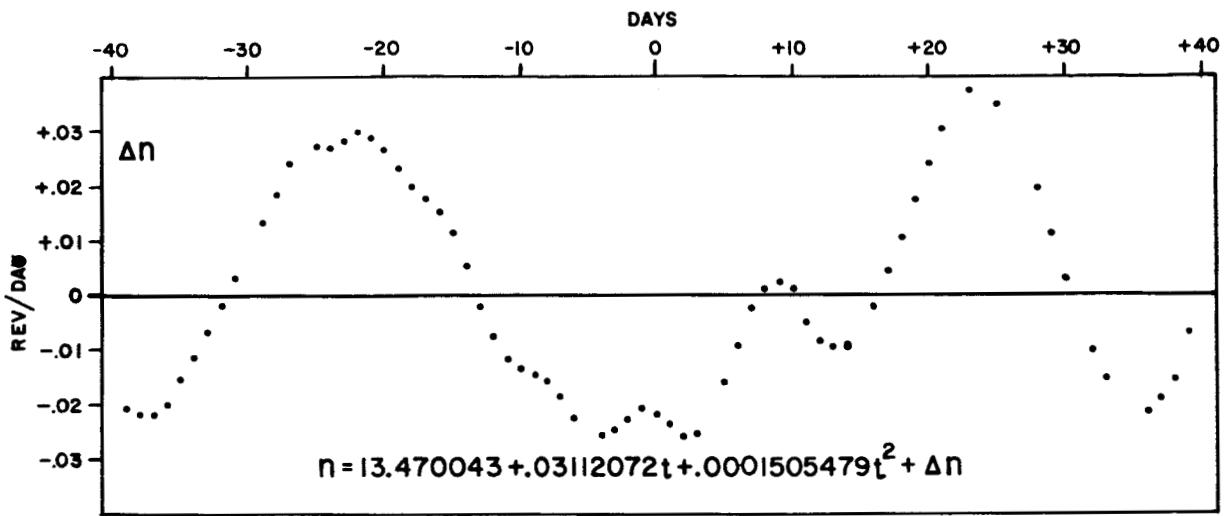


FIGURE 4. - VARIATIONS IN THE MEAN MOTION OF SATELLITE 1958 GAMMA.

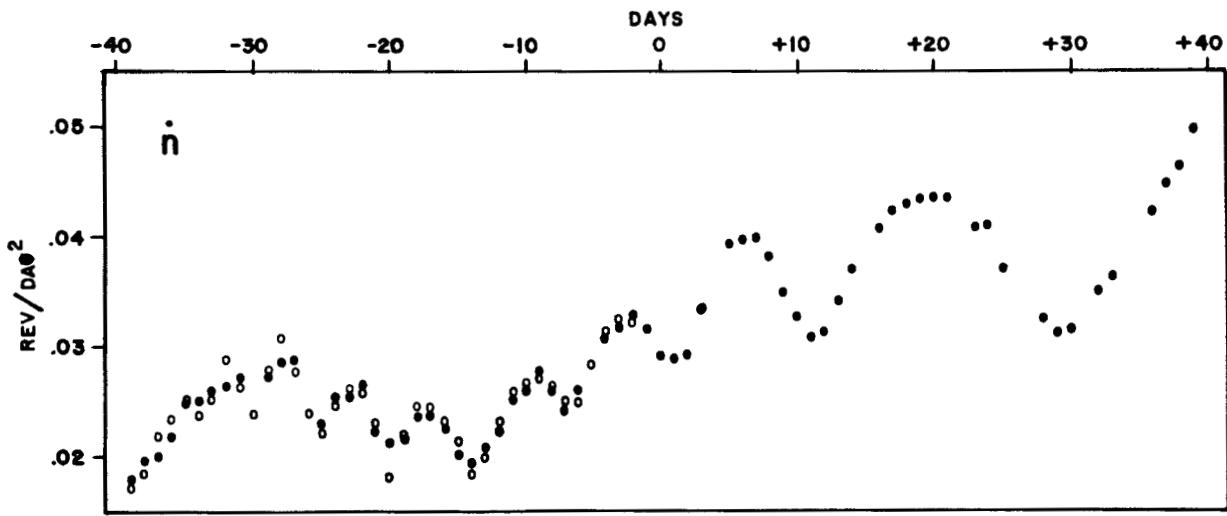


FIGURE 5. - THE DERIVATIVE OF THE MEAN MOTION OF SATELLITE 1958 GAMMA AS DETERMINED BY THE SAO DIFFERENTIAL ORBIT IMPROVEMENT PROGRAM, REPRESENTED BY FILLED CIRCLES. OPEN CIRCLES REPRESENT THE CORRESPONDING VALUES OBTAINED BY J. W. SIRY AND PRESENTED AT THE TENTH GENERAL ASSEMBLY OF THE IAU IN MOSCOW, AUGUST 1958.

RELATIVE POSITIONS OF THE SUN AND THE PERIGEE
OF AN ARTIFICIAL SATELLITE

by

Pedro E. Zadunaisky¹

A correlation between variations of solar activity and variations of atmospheric density, derived from the motions of satellites, has been established (Jacchia, 1959; 1960). We have therefore written a machine program to compute some of the variables involved. They are given in Table 5 as functions of time.

The time T is reckoned in Julian Days; however, to avoid repetitions, we have subtracted from every Julian Date the number 2400000.5. Given an initial date T_0 , we compute the argument of perigee, the right ascension of the node, and the inclination of the orbit by the following formulas:

$$W = W_0 + W_1 T + W_2 T^2 + W_3 T^3 + W_4 \sin (W_5 + W_6 T) + W_7 \sin (W_8 + W_9 T) ,$$

$$\Omega = \Omega_0 + \Omega_1 T + \Omega_2 T^2 + \Omega_3 T^3 + \Omega_4 \sin (\Omega_5 + \Omega_6 T) + \Omega_7 \sin (\Omega_8 + \Omega_9 T) ,$$

$$i = i_0 + i_1 T + i_2 \sin (i_3 + i_4 T) ,$$

where $T = J.D. - T_0$.

The coefficients have been obtained partly by theoretical methods and partly by empirical methods, from an analysis of observations by a differential correction process. Then the right ascension α and the latitude of perigee ϕ are computed by known formulas of spherical astronomy.

Formulas and data given in the American Ephemeris and Nautical Almanac of 1960, page 498, are used to compute the true longitude of the sun, referred to the mean equinox of the epoch, and the mean obliquity of the ecliptic. Next, we compute the right ascension of the sun, to which a constant D (given in advance) can be added to allow for a possible delay of the solar effect on the atmospheric density. Then we compute ψ , the geocentric angular distance from the sun to the satellite's perigee, and $\Delta\alpha$, the difference in right ascension between perigee and sun; these quantities, of course, will be affected by the correction D introduced in the right ascension of the sun and their true values should be obtained when $D = 0$. Finally, if the distance from perigee to the center of the earth is known, the height of perigee above the International Ellipsoid of Reference is obtained by subtracting the equatorial radius (6378.388 km) and adding the correction C(km) computed by the formula

$$C(km) = 21.476 \sin^2 \phi$$

All angular measurements are in degrees, and C(km) is in kilometers.

¹ Astronomer, Smithsonian Astrophysical Observatory.

References

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1959. Solar Effects on the Acceleration of Artificial Satellites. Special Report No. 29,
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Report No. 39, Smithsonian Astrophysical Observatory, pp. 1-15.

CORRECTIONS FOR SPECIAL REPORT NO. 28

Special Report No. 28 contained errors to be corrected as follows:

Page 5, last line, instead of "May 26" read "April 26";

Page 6, last line, instead of "May 26" read "April 26";

Page 7, line 13, instead of "± km" read "± 5 km."

General Notice -- This series of Special Reports was instituted under the supervision of Dr. F. L. Whipple, Director of the Astrophysical Observatory of the Smithsonian Institution, shortly after the launching of the first artificial earth satellite on October 4, 1957. Contributions come from the Staff of the Observatory. First issued to fulfill a demand for the rapid dissemination of satellite tracking data, the Reports have continued, to ensure the rapid communication of current satellite data, data analyses, and material relating to progress in the astrophysical and space sciences.

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The Reports are produced under the supervision of Mrs. L. B. Davis, and edited by Mrs. L. G. Boyd.

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